

## 1 BACKGROUND

Fugro EarthData (Fugro) was tasked as the Quality Control (QC) manager for the North Carolina statewide orthophotography project under AECOM's North Carolina contract. The main responsibilities covering this task were to do a quality assurance check of the aero triangulation (AT) report, ensure orthophotography tiles were standardized in their delivery, perform a percentage check of tiles for errors, and generate MrSID tiles and mosaics for all accepted data.

## 2 PROCEDURE

To achieve the quality objectives Fugro designed the following process that was implemented during the AT QC execution. Fugro was not tasked to seal the AT results but to do a quality assurance check of the results.

### 2.1 Block Integrity Check:

In this step, the actual block layout compared to the executed AT block to ensure that the contractor adhered to the original design of AT blocks and ground control layout. Discrepancies were sent back to the contractor for correction.

### 2.2 Ground Controls Integrity Check:

This step was performed at the same time as 2.1. The ground control numbers and configuration are examined and any discrepancies were reported for correction or clarification (see figure 1).

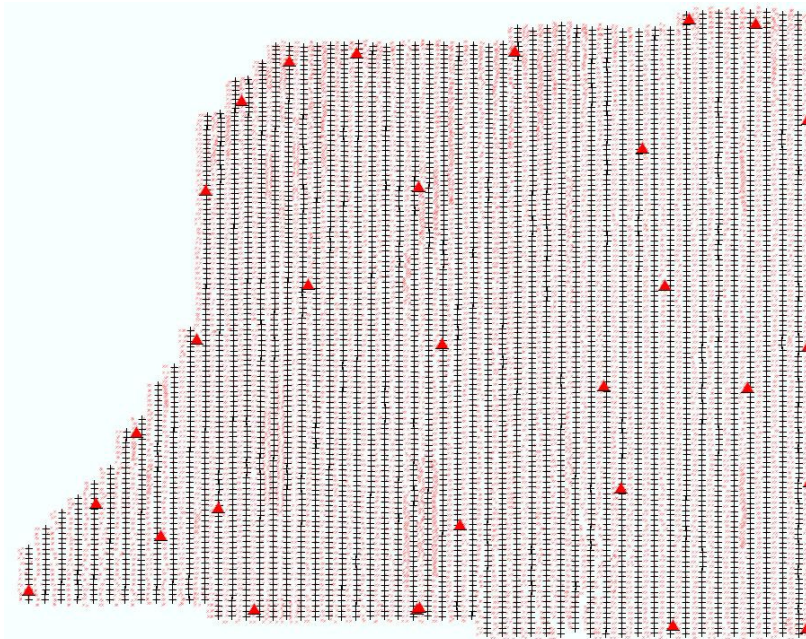


Figure 1 Photo centers, tie/pass, and control layout

### 2.3 Tie/pass points Integrity Check:

In this step a visual examination of the density and distribution of the tie/pass points was performed (see figure 1) and discrepancies were reported for correction or clarification.

## 2.4 Bundle Block Adjustment Setup Examination:

In this step, the final report from the bundle block adjustment was examined in order to make sure that the statistics meet the final project accuracy specifications. Final accuracy specifications were developed for the project after the first few blocks were submitted for review and it became clear that vendors needed more guidance on the measure of acceptability (Figure 2). Details of bundle adjustment setup (see figure 3) and weight on the ABGPS and ground control points (see figure 4) are reviewed and discrepancies were reported for correction or clarification.

	Tested Characteristic	Measure of Acceptability
40.	Horizontal accuracy against ground control check points tested in accordance with 10+ points at NSSDA criteria	RMSE = 0.8 ft for imagery with 6" GSD (to support ortho generation according to ASPRS mapping standard class II)
41.	Vertical accuracy against ground control check points tested in accordance with 10+ points at NSSDA criteria	0.8 ft for imagery with 6" GSD (to support ortho generation according to ASPRS mapping standard class II)
42.	Accuracy against image coordinates	RMSE less than or equal to 5 microns is acceptable.
43.	Max. offsets [E, N] to any one blind QA point	3 * RMSE or 2.4 ft
44.	RMSE at airborne GPS residuals in E,N,H	Acceptable RMSE at GPS residuals generally less than 15 cm.

Figure 2 AT accuracy specifications

GCP observations: Enabled  
GPS observations: Enabled  
IMU observations: Enabled  
Error Detection: Disabled  
Self-Calibration: Disabled  
Precision Computation: Enabled

Figure 3 Block adjustment setup

ID	X	Y	Z	VX	VY	VXY	VZ	Std Dev X	Std Dev Y	Std Dev Z	rx	ry	rz	RMSVX	RMSVY	RMSVZ
652124	1483337.5500	846357.2400	5601.2400	0.1430	-0.0259	0.1453	0.2341	0.1599	0.1702	0.0968	0.22	0.12	0.71	0.0854	0.0624	0.1533
652123	1483339.3600	844907.4900	5605.0500	0.1368	-0.1818	0.2275	0.3451	0.1469	0.1600	0.0817	0.34	0.22	0.80	0.1062	0.0852	0.1618
652122	1483350.4600	843441.6800	5604.3900	0.2439	-0.2686	0.3628	0.2178	0.1444	0.1591	0.0776	0.37	0.23	0.82	0.1096	0.0869	0.1638
652121	1483360.0600	841964.7000	5599.6500	-0.0421	-0.2888	0.2918	0.1812	0.1461	0.1619	0.0784	0.35	0.20	0.81	0.1073	0.0815	0.1634
652120	1483368.6600	840491.9700	5594.8600	0.1492	-0.2969	0.3323	-0.0627	0.1491	0.1625	0.0807	0.32	0.20	0.80	0.1031	0.0803	0.1623
652119	1483366.6800	839017.6800	5597.7800	-0.0071	-0.1864	0.1865	0.0455	0.1466	0.1586	0.0801	0.35	0.23	0.80	0.1066	0.0878	0.1626
652118	1483360.1800	837528.8300	5599.3000	0.1478	-0.2209	0.2658	0.0133	0.1481	0.1602	0.0807	0.33	0.22	0.80	0.1046	0.0849	0.1623

Figure 4 Weight and accuracy of adjusted parameters of the ABGPS

## 2.5 Bundle Block Adjustment Results Examination:

In this step, the final results of the ground controls fit were examined in order to ensure that it was meeting the contractual specifications (see figure 5)

	Parameter	X/Omega	Y/Phi	Z/Kappa	XY
	RMS Control	0.268	0.242	0.240	0.361
	RMS Limits	1.000	1.000	1.000	
	Max Ground Residual	0.499	0.649	0.625	
	Residual Limits	3.000	3.000	3.000	
	Mean Std Dev Object	0.08471	0.07992	0.19470	
	RMS Photo Position	0.095	0.177	0.115	
	RMS Photo Attitude	0.006599	0.004279	0.021666	
	Mean Std Dev Photo Position	0.1527	0.1637	0.0865	

Mean Std Dev Photo Attitude 0.001930 0.001662 0.000975

Current Count

Control Points Used: 30  
Photos Used: 5104  
Photos Not Used: 0  
Image Points Used: 17089

*Figure 5 Final accuracy of adjusted block*

### 3 ISSUES ENCOUNTERED

The following issues were observed in various AT reports and communicated back to the vendor and the program manager.

#### 3.1 Blocks design deviated from the original block design:

Some contractors altered the boundary of the blocks due to various legitimate and illegitimate reasons. Among the legitimate reasons were terrain difficulty which made it impossible to collect ground controls as it was laid out in the original design, therefore the blocks were re-aligned to better fit the surveyed ground controls.

#### 3.2 Not enough tie/pass points between adjacent blocks:

Some blocks did not have enough tie points in order to assure accurate transition from one block to another.

#### 3.3 Assigned priority weights were either too loose or too tight:

Some contractors applied unsuitable constraints on the adjusted observations in the AT bundle block adjustment.

### 4 RESOLUTIONS

Based on the issues encountered three resolutions could be applied to avoid such encounters on future programs.

- AT accuracy specifications should be specified clearly at the RFP or contracting stage so that vendors clearly understand the production expectations. This would also ensure proper AT block design and ground control point (GCP) design.
- Adding blind points at the AT stage would allow vendors and QC firm/s to confirm the quality of the AT solution.
- Ensure that the difficulty of terrain be taken into account during the design of the AT blocks and the GCP layout development.

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